Development of an Earthquake Casualty Model for New Zealand

Nick HORSPOOL[1,2] (n.horspool@gns.cri.nz), Ken ELWOOD[1], David JOHNSTON[2,3], Michael ARDARGH[4], Joanne DEELY[4]

[1] Department of Civil & Environmental Engineering, University of Auckland, New Zealand
[2] GNS Science, Lower Hutt, New Zealand
[3] Joint Centre of Disaster Research, Massey University, New Zealand
[4] RHISE Group, University of Otago, New Zealand

Introduction

In the past 8 years, earthquakes in New Zealand have injured over 16,000 people and killed 187, resulting in a significant impact on the affected individuals, families, businesses and communities across the country. Understanding the key drivers of earthquake casualties (injuries and fatalities), and being able to forecast casualties, are important for reducing the socio-economic impact of future earthquakes.

Existing New Zealand and Global Casualty Models

Previous research that has investigated casualty risk factors and developed models to forecast earthquake casualties globally and in New Zealand have a number of significant limitations.

First, they are based on simple dependent variables such as ground shaking intensity (e.g. Jaiswal & Wald, 2010) or building damage (e.g. Cousins et al 2008, Spence et al, 2011). Preliminary investigations on injuries from the Canterbury Earthquake Sequence have shown that nearly 50% of injuries were from peoples actions (Johnston et al, 2014) indicating that behavioural variables, amongst other demographic variables, need to be considered.

Second, previous casualty models use injury data that is biased towards the more severe injuries states as this is what is generally reported internationally, or the data is dominated by countries where building codes are not present or not enforced and have little relevance with New Zealand.

Third, there is very little empirical data or research globally that accounts for the cost of casualties, including direct medical cost, lost time of wages/salaries, and indirect economic costs. To enable robust cost-benefit analysis of earthquake risk mitigation measures (e.g. retrofitting) the cost of injuries needs to be quantified and modelled.

Addressing these limitations by considering a multi-disciplinary approach to statistical analysis of casualties, using globally unique casualty data, and tracking the costs of casualties will be the novel aspects of this research.

Casualty Data from Recent New Zealand Earthquakes

This project will utilise globally unique earthquake casualty data that has been collected and processed by the RHISE Group (Researching the Health Implications of Seismic Events) based out of the University of Otago Medical School and Canterbury District Health Board. The RHISE Casualty Database consists of four databases:

- ACC Injury Claims (~16,000 people): This data includes 8 earthquake events from the 2010 Darfield earthquake to the 2016 Kaikoura Earthquake. It includes descriptions of cause of injury, type of injury and cost. One limitation is it does not contain information to geolocate the injury to a building.

- RHISE Follow Up Survey (~1400 people): The RHISE Group undertook a follow up survey of people registered in the ACC database that were injured in the Canterbury Earthquake Sequence. The survey had a 9% response rate. The data from the survey includes more information on cause of injury and the location which allows matching with individual buildings.

- Canterbury District Health Board Data (~15,000 people): This data includes more detailed information related to the treatment, costs and pathway through the medical system for casualties from the Canterbury Earthquakes.

- Coronial Data (185 people): This includes all coronial enquiry data from deaths during the Canterbury Earthquakes.

Research Objective and Methods

To develop an earthquake casualty model that can forecast *casualty states* and *costs* **to inform pre-earthquake planning and risk mitigation, and post-event response.**

The project will aim to take a novel multi-disciplinary view of earthquake casualties, considering seismological, engineering, behavioral and socio-economic variables.

ACC injury claim and coronial data will be correlated with seismological data, including variables such as shaking intensity, frequency and duration, engineering data, including building type and damage, behavioural response, and social-economic data of the individual. Statistical analysis will then be undertaken to identify key variables that are correlated with earthquake injuries.

A statistical model will be developed to enable forecasting of casualties and costs from future earthquake scenarios. This model will then be used to undertake a New Zealand earthquake injury risk assessment as well as for several credible earthquake scenarios.

Proposed Outputs and Outcomes

The proposed outputs and outcomes from the project are:

- An improved understanding of key risk factors of earthquake injuries and fatalities from recent New Zealand earthquakes. This will include seismological, engineering, behavioral and socio-economic factors, and will enable prioritisation of risk mitigation activities for reducing earthquake casualties.

- A statistical model that will enable forecasting of casualties (probability of being in a casualty state) from future earthquakes in New Zealand and globally. This may include a number of sub-models with different levels of granularity. For example a Level 1 model might be a single dependent variable such as shaking intensity for rapid post event analysis. A Level 2 model might include multiple variables but fit within the PEER Loss Assessment framework. A Level 3 model might include all significant dependent variables and be uniquely configured for New Zealand.

- A statistical model that enables quantification of the direct and indirect costs of earthquake casualties.

- These models could be used for:
    - Pre-earthquake scenario planning
    - Pre-earthquake risk assessment and cost-benefit analysis of mitigation actions (e.g. education, Earthquake Early Warning Systems, retrofitting)
    - Post-earthquake rapid estimation of casualties and socio-economic impacts

References

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